Brachycephalic obstructive airway surgery outcome assessment using the 6-minute walk test: a pilot study

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Brachycephalic obstructive airway syndrome (BOAS) is used to describe a combination of upper airway problems in brachycephalic dog breeds (such as English bulldogs, French bulldogs and pugs) that lead to partial obstruction of the upper respiratory tract (Lecoindre & Richard 2004, Packer 2013). Many affected dogs require surgical intervention such as rhinoplasty, soft palate resection and laryngeal sacculectomy (Meola, 2013). The outcome of BOAS surgery has been subjectively evaluated with 88 to 94% of dogs showing improvement after surgery according to owner questionnaires (Poncet et al. 2006, Torrez & Hunt 2006, Riecks et al. 2007, Pohl et al. 2016). Whole-body barometric plethysmography can objectively evaluate respiratory function (Bernaerts et al. 2010, Liu et al. 2015) and has shown a significant improvement in respiratory function after surgery but, in contrast, a simple objective assessment of respiratory function has not been reported.

The 6-minute walk test (6-MWT) is a safe and simple test that is commonly used to assess functional exercise capacity in humans with impaired cardiorespiratory function (Olsson et al. 2005, Bellet et al. 2012). The 6-MWT has been assessed in dogs with idiopathic pulmonary fibrosis (Lilja-Maula et al. 2014), induced obesity (Manens et al. 2014) and induced congestive heart failure (Boddy et al. 2004).

The aim of this pilot study was to assess the practicality and feasibility of the 6-MWT in brachycephalic dogs as a test for assessment of functional exercise capacity after airway surgery.

Materials and methods

Recruitment of dogs

Privately owned pugs, French bulldogs (FB) and English bulldogs (EB) clinically affected by BOAS were prospectively recruited between August 2015 and February 2016 at the Queen Mother Hospital for Animals (Royal Veterinary College, London). Dogs were excluded if they were oxygen-dependent and deemed unable to be without supplemental oxygen to allow the 6-MWT to be performed, or had severe orthopaedic or neurological disease that impaired walking. None of the recruited dogs had detectable cardiac disease at the time of the study. Body condition score was recorded based on a 1 to 9 scale on which 4 to 5 is considered ideal. Approval from the Queen Mother Hospital for Animals Ethics and Welfare committee had been granted (URN 2015 1337).

6-MWT and measured values

Dogs were walked along a 75-m corridor at a quiet time, for 6 uninterrupted minutes. Dogs were walked on a leash with a harness and were allowed to walk at their own pace and to stop if needed. The 6-MWT was performed by two of the investigators (EV, LR). The distance walked (forward motion only) within the 6 minutes was recorded in metres.

Heart rate, respiratory rate and oxygen saturation (SpO2) by pulse oximetry (Viamed Ltd, VM-2500-S) were recorded before walking, immediately after walking and 2 and 5 minutes after the exercise test. Rectal temperature was recorded before and immediately after the walk. SpO2 was recorded on the ear, lip or prepuce.

Data collection

The 6-MWT was performed for all dogs before BOAS surgery (and before any sedation/anaesthesia) after being hospitalised for a few hours as an acclimatisation period, approximately 24 hours after surgery, and again at least 6 weeks after surgery. Preoperative

57 evaluation included clinical scoring according to the Poncet clinical scoring system (Poncet et
58 al. 2005); this clinical scoring is based on the frequency of snoring, inspiratory effort,
59 exercise intolerance and syncope. All dogs were anaesthetised using the same protocol under
60 supervision of a ECVAA board-certified veterinary anaesthetist. Oropharyngeal examination
61 included description of stenotic nares, presence of elongation of the soft palate and degree of
62 laryngeal collapse. A subjective evaluation of degree of stenosis of the nares was made as
63 follows: mild stenosis of the nares (narrowing of the nostril by <25% compared to what is
64 considered a "normal adequate" opening of the nostril for the breed); moderate stenosis of the
65 nares (narrowing of the nostril of between 25 and 50%) and severe stenosis of the nares
66 (narrowing of the nostril of >50%). Laryngeal saccule eversion was seen in all animals and
67 considered to be part of a grade 1, 2 or 3 laryngeal collapse. The physical examination was
68 performed on all the included cases by the same ECVS board-certified surgeon. After
69 oropharyngeal examination, CT of the head, neck and thorax was performed. Tracheal
70 hypoplasia was not evaluated.
71
72 BOAS surgery consisted of partial staphylectomy, using a modified technique described by
73 Bright & Wheaton (1983). Briefly, the palate was sharply cut with Metzenbaum scissors in an
74 arch shape, taking most tissue from the medial part of the soft palate, approximately to the
75 level of the cranial third of the tonsils. The oropharyngeal and nasopharyngeal mucosa were
76 apposed using simple interrupted absorbable sutures (Bright & Wheaton 1983, Riecks et al.
77 2007) (polyglactin 910, Vicryl Rapide™, Ethicon Inc.). A modified horizontal wedge
78 resection rhinoplasty was also performed (Schmiedt & Creevy 2011) and closed with simple
79 interrupted absorbable sutures (Monocryl®, polyglecaprone 25, Ethicon Inc.). Laryngeal
80 sacculectomy was not performed in any patient. All the surgeries were performed by the
81 same ECVS board-certified surgeon or ECVS resident under direct supervision.

Statistical analysis

Statistical analysis was performed using commercially available software (SPSS version 22). Mean ±sd values are given for age and body weight of all dogs and for distance walked, heart rate (HR), respiration rate (RR), temperature and SpO2 for each time point. Repeated measures analysis of variance (ANOVA) were used to compare the distance walked, HR, RR, temperature and SpO2 between the different time points and between the different tests (preoperatively, 24 hours postoperatively and 6 weeks postoperatively). P values <0·05 were considered significant.

One-way ANOVA were used to compare the distance walked between different grades for stenotic nares, elongation of soft palate, nasopharyngeal turbinate protrusion, laryngeal collapse and Poncet clinical score. P values <0·05 were considered significant.

Results

Patients and preoperative assessment results

A total of 24 dogs were recruited to this pilot study: 10 FB, nine EB and five Pugs. Seventeen dogs were male (12 entire, five neutered) and seven were female (five entire, two neutered). The mean (±sd) age was 21·7 (±16·6) months (range 4·6 to 79 months). The mean (±sd) weight was 15 (±7·7) kg (7·2 to 34·6 kg) and none of the dogs were considered clinically obese. According to the Poncet clinical scoring system 83% of the dogs were grade 3, 11% of dogs were grade 2 and 6% were grade 1. Nose and oropharyngeal examination findings are presented in Table 1. CT findings included nasopharyngeal turbinate protrusion of grade 1 in seven dogs, grade 2 in six dogs, grade 3 in four dogs and grade 4 in three dogs (Vilaplana Grosso et al. 2015). All dogs performed the preoperative and 24 hours postoperative 6-MWT. Four dogs did

not perform the 6-week postoperative 6-MWT because of failure to attend. These four dogs were excluded from the repeated measures ANOVA analysis.

Results of 6-MWT

The results for HR, RR, SpO2, rectal temperature and distance walked are presented in Table 2. Fig. 1 also shows the distance walked by each dog at the different 6-MWT. There was a significant change in distance walked by each dog at 6 weeks postoperatively compared to preoperatively, with an average increase of 13·7 ± 28·8% (range −31·3 to 66·6%). At 24 hours postoperatively there was a significant decrease in distance walked, HR and temperature. There was no significant difference in distance walked for the different grades of clinical scoring or anatomical abnormalities.

Discussion

In this pilot study, the 6-MWT was feasible and relatively easy to perform on brachycephalic dogs. Most dogs demonstrated an improvement in distance walked on the >6 weeks 6-MWT consistent with improved cardiopulmonary function after airway surgery.

The clinical signs were evaluated using the Poncet respiratory clinical scoring system (Poncet et al. 2005): 83% of our dogs fell in the grade 3 for respiratory signs, in line with the previous reports (Poncet et al. 2006, Torrez & Hunt 2006, Pohl et al. 2016). No significant difference in distance walked was found for the different clinical scores perhaps as type II error because of the small sample size. Postoperative Poncet clinical scoring was not performed in this study, which prevented comparison with the postoperative 6-MWT.

Although assessment of outcome after BOAS surgery currently mainly relies on the perception of the owner (Poncet et al. 2006, Torrez & Hunt 2006, Riecks et al. 2007, Pohl et al. 2016), they may not recognise respiratory compromise in their dogs (Packer 2013, Liu et al. 2015) and there may well be individual variability in owner assessment. The 6-MWT would allow assessment of large numbers of dogs and could allow for evaluation of the influence of type of surgery or clinical grade on the outcome after BOAS surgery.

Our study showed an average increase of 13·7% in the distance walked during the 6-MWT at 6 weeks after BOAS surgery, indicating an improved exercise tolerance. However, not all individual dogs demonstrated an improvement. Four dogs, all EBs, demonstrated decreased exercise tolerance. Four dogs, all FBs, walked 35 to 66% further after surgery compared to before. This could possibly be because FB are more afflicted with anatomical abnormalities that are amenable to surgery, but larger numbers of dogs would need to be examined to investigate this in more detail. Tracheal hypoplasia and thickness of the soft palate (as opposed to length) were not evaluated and could also have influenced our results.

Our results also show a decrease in resting respiratory rate and an increase in SpO2 following surgery. SpO2 measurement can be insensitive and variable when using pulse oximetry, which could explain the wide range of measures obtained, and the changes might not be clinically important. Arterial oxygen saturation measurement is more reliable but is not easily accessible for all patients. Arterial blood sampling was not deemed clinically necessary for these patients. The decrease in resting respiratory rate at 6 weeks after surgery might reflect an improvement in respiratory function although the change observed is small and might not be clinically important.

Interestingly, the 6-MWT results obtained at 24 hours after surgery were generally worse than those just before surgery. We consider that this might be a consequence of the recent general anaesthesia and concurrent opioid analgesia, and/or surgery-related swelling.

In our results, the distance walked (mean 446 m before surgery) is still far lower than that published for other breeds; Manens et al. (2014), Boddy et al. (2004) and Swimmer & Rozanski (2011) report mean distances walked of 589, 573 and 522·7 m in healthy beagles, research hounds and various breeds, respectively. This difference likely highlights the brachycephalic-related exercise intolerance, although direct comparison between studies is difficult and other factors such as stride length or leg height could also account for the differences. In these reports, control dogs walked 9 to 33% more in the 6-MWT than affected dogs (namely obese dogs, dogs in congestive heart failure and dogs with pulmonary disease). The 6-MWT could be used to explain and demonstrate the severity of BOAS to pet owners and as a screening tool for breeding to detect the most clinically affected dogs and thus be used to decrease the severity of respiratory compromise that greatly impacts the quality of life of these popular pets (Packer 2013, Liu et al. 2015).

A limitation of this study was the small number of dogs included, and the fact that four dogs did not attend their postoperative 6-MWT. This could have influenced results (as the owners might have declined re-examination because patients were either doing very well or owners may instead have been dissatisfied with the surgery), and decreased the power of the study. A larger number of dogs would be needed to assess breed-related, gender-related or body condition score-related changes in the 6-MWT and its correlation with anatomical abnormalities and clinical grade.

Although each patient acted as its own control and the test was designed to be repeatable and met the recommended guidelines (Enright 2003), the breed, temperament, body condition score, concurrent undetected conditions or overall fitness level of each dog could influence results of the 6-MWT. Patients might refuse to walk, some might perform better with repeated testing (although in our study the 6-MWT was performed 6 weeks apart), and some might have occult orthopaedic or cardiac disease affecting their exercise capacity. Daily intra-patient variability has not been assessed for the 6-MWT.

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Figure 1. Distance in metres walked by each dog for the 6-minute walk test at the different time points

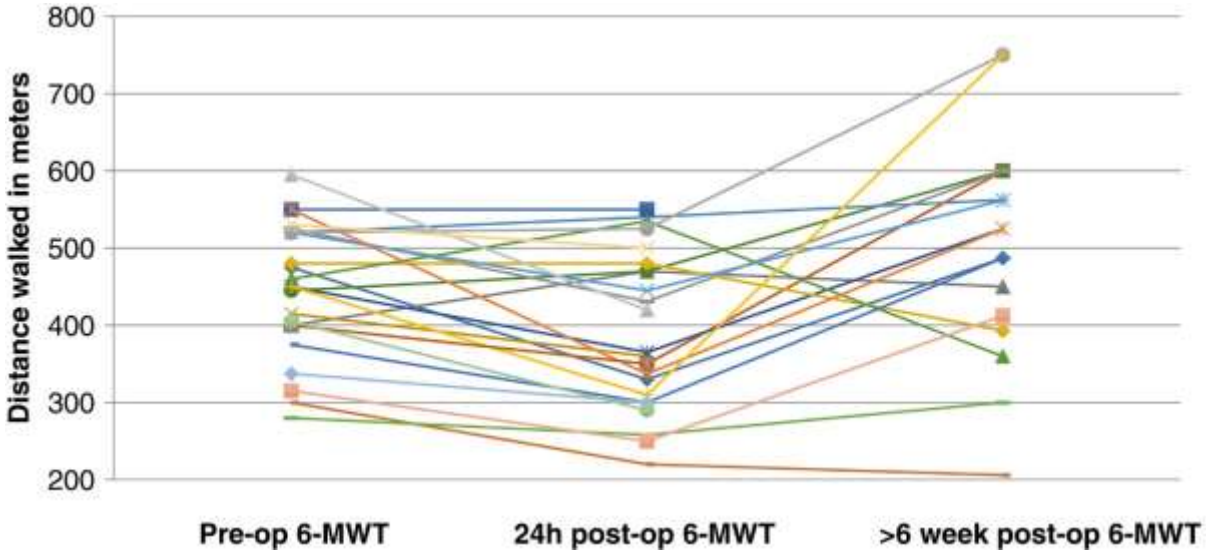

Table 1. Nose and oropharyngeal examination findings including degree of stenotic nares, elongation of the soft palate, laryngeal collapse and nasopharyngeal turbinate protrusion

	Not recorded	**Mild**	**Moderate**	**Marked**	
Stenotic nares	3	3/21 (14·3%)	7/21 (33·3%)	11/21 (52·4%)	
Elongation of the soft palate	4	0	7/20 (35%)	13/20 (65%)	
	Not recorded	Grade I	Grade II	Grade III	
Laryngeal collapse	3	3/21 (14·3%)	16/21 (76·2%)	2/21 (9·5%)	
	Not recorded	Grade I	Grade II	Grade III	Grade IV
Nasopharyngeal turbinates	3	7/21 (33·3%)	6/21 (28·6%)	4/21 (19%)	3/21 (14·3%)

Table 2. Means (±sd) for heart rate, respiratory rate, SpO_2 and rectal temperature for all times points for each 6-MWT. Means (±sd) and range for distance walked for each 6-MWT

		Preoperative	**24-hour postoperative**	**>6 weeks postoperative**
Heart rate (mean beats per minute)	Pre	107 (±22)	93 (±18)	100 (±19)
	Immediately post	126 (±25)	111 (±25)	115 (±26)
	2 min post	117 (±21)	103 (±24)	111 (±30)
	5 min post	109 (±21)	96 (±20)	99 (±14)
Respiratory rate (mean breaths per minute)	Pre	48 (±27) *	52 (±46)	35 (±15)*
	Immediately post	82 (±48)	70 (±39)	103 (±56)
	2 min post	80 (±53)	72 (±51)	102 (±54)
	5 min post	68 (±45)	70 (±46)	82 (±43)
SpO2 (mean %)	Pre	94 (±3) *	94 (±5)	96 (±2)*
	Immediately post	93 (±6) *	95 (±4)	95 (±3)*
	2 min post	93 (±5) *	95 (±3)	97 (±1)*
	5 min post	95 (±3) *	96 (±3)	97 (±2)*
Temperature (mean degrees Celsius)	Pre	38·2 (±0·5)	37·7 (±0·5)	38·4 (±0·5)
	Post	38·6 (±0·5)	38·1 (±0·7)	39·0 (±0·5)
Distance walked in metres		446 (±85) * (280 to 595)	391 (±101) (220 to 550)	504 (±144)* (206 to 750)

* Statistical significance between preoperative and >6 weeks postoperative